An increase in the bankful capacity of the main stream at critical sections is proposed, but channel enlargement to provide for flood-flow capacity is not feasible.

Reservoir sites.—Many of the destructive floods which occur in the Minnesota River Valley are local in character. Flood producing conditions seldom, if ever, occur simultaneously with equal intensity over such large and diverse areas as those included within the Minnesota River drainage basin. Early spring floods caused by the melting of accumulations of snow come nearest to being general throughout the entire valley. The most destructive floods, however, are those which occur during the crop season. Since they are largely due to flood flows from individual tributaries, these summer floods are normally much more severe in one part of the valley than in the remainder. If these floods are to be prevented by retarding the flood waters until the available channels can carry them away, then reservoirs must necessarily be located in various portions of the drainage basin.

Four "reasonably satisfactory" sites for the location of reservoirs were found near Ortonville, Montevideo, Delhi, and New Ulm. Big Stone Lake, near Ortonville, with an area of about 20 square miles, can be used for retarding the flood waters of the Little Minnesota and Whetstone Rivers. These are extremely flashy streams that at times cause much damage in the upper valley.

Lac qui Parle, above Montevideo, area about 4 square miles, constitutes a natural reservoir, which, with Marsh Lake and large adjoining areas of marsh and low-lying agricultural lands, can be utilized for retarding the flood waters of the Lac qui Parle and the Chippewa Rivers.

Near Delhi there is a possible site which could be used for combined power and flood protection, reducing the flood crests of the Yellow-Medicine River and Hawk Creek. The flood protection feature of this project is not considered to be important.

The New Ulm reservoir would store the water above the mouth of the Cottonwood River. This river flows so rapidly that its flood waters now flow up the Minnesota and fill the valley before the upper tributary waters arrive, and the two proposed upper reservoirs would provide only incomplete protection to the valley around New Ulm.

The storage capacity of three of the four proposed reservoirs would be as follows:

Big Stone Lake, 4 billion cubic feet.
Lac qui Parle reservoir, 9 billion cubic feet.
New Ulm, 5.5 billion cubic feet.

A reservoir on the Blue Earth River is thought to be unnecessary, as its flood waters coming from the south usually pass Mankato before the arrival of the Cottonwood water, and retardation of the Blue Earth would only aggravate conditions at Mankato.

Automatically controlled retarding basins, such as those used on the Miami River, are inapplicable to the Minnesota basin, mainly on account of the long duration of the floods and the irregularity of the flood-producing combinations.

On account of the rapidly increasing channel capacity from Big Stone Lake to Mankato, the size of flood protection reservoirs provided per square mile of tributary drainage area should increase *upstream.* The channel below Big Stone Lake, for example, has a capacity only about one-tenth as large as that of the channel below Montevideo, even though the drainage area tributary to Big Stone Lake is one-fifth as great as that tributary to the Minnesota at Montevideo. Such reservoirs should also be relatively larger for small basins than for large ones, because the smaller the area the larger the rainfall and run-off in inches depth over that area, which will occur with given frequency.

In the operation of the proposed reservoirs within the limits of their capacity no water should be discharged from any one of them until it is full, or the stage in the reservoir next below it is falling, indicating that the inflow is less than the outflow. In general, this means that the upper reservoirs should be filled first and emptied last; or, in other words, the storing of water should continue in the upper reservoirs until wasting has begun in the reservoir next below. During sudden freshets on the tributaries between any two reservoirs the wasting of flood water from the reservoir above should be temporarily suspended.

The report also contains interesting paragraphs on probable flood frequency in the Minnesota River Valley, the economic value of flood protection, meteorological tables, and other flood statistics. It is the opinion of Mr. Meyer that floods like those in the upper valley in 1919 are not likely to be approached oftener than once in 40 years, and that bankful stages are probable every year in the lower valley and every two years above. Tables and curves were used to form an estimate of the depreciation of cultivated lands by flooding during the crop season, and they indicate that land on which a grain crop is lost once in every three years has no capital value for cultivation purposes. As flood losses become less frequent, land values increase rapidly until only one crop is lost every 10 or 15 years; beyond this point the increase in capital value is very slow.—*H. C. F.*

THE INFLUENCE OF FOREST AREAS IN NONFORESTED REGIONS UPON EVAPORATION, SOIL MOISTURE, AND MOVEMENT OF GROUND WATER.[1]

By Prof. IRWIN T. BODE.

[Dept. of Forestry, Iowa State College, Ames, Iowa.]

[Author's Abstract.]

[Read before Iowa Academy of Sciences, Annual meeting, 1920.]

The paper includes the results of a series of studies carried on in the northeastern part of Iowa during the summer of 1919. The work covers the comparison of the evaporation and soil moisture conditions obtaining on forested and nonforested sites, and the influence that the forested areas have as to the checking of run-off, the absorption of moisture into the soil, and the response of the various soils at various depths to precipitation.

The direct influence of forest cover in checking the rate of evaporation is emphasized, there being a distinct decrease in evaporation with the succession from open to brushy and in turn to timbered sites. There is also evident a rather direct relation between the rate of evaporation and the aspect of slopes, and between the evaporation and the wind velocity.

The studies of soil moisture show the tendency of the timbered soils to a higher moisture content and the greater absorbtive qualities. There is apparent a direct relation of the forest cover to the checking of the run-off and to the rate of permeability of soil moisture to the lower soil layers. The movement of ground water appears to be distinctly retarded in the case of the timber soils. The results all indicate the importance of forest cover on the slopes of watersheds, even where the forest areas are comparatively limited in extent.

[1] To be published at Des Moines, Iowa, in the *Proceedings of the Iowa Acad. of Sci.*, for 1920.

DISCUSSION.

With reference to evaporation, the thing which Prof. Bode measured was essentially the evaporative capacity with reference to the porous cup atmometer and its environment. This is the same thing which has been described by Livingston and others as "the evaporative power of the air."

Evaporative capacity, and the evaporative loss from the soil, may be, and usually are, quite different, the former being the larger, since the latter is the product of the evaporative capacity and a factor termed by the writer "Evaporative Opportunity," and which is approximately proportional to the percentage of saturation of the soil surface, and is generally less than unity.

If, therefore, when Prof. Bode speaks of evaporation, it is assumed that he means "Evaporative Capacity," and not actually evaporation loss from the soil, then his conclusions are undoubtedly correct, and are in accordance with numerous other investigations along the same line.

More experimental work is needed to determine the precise relations of the actual evaporation loss from the soil in woods, sodded fields, and cropped fields. Very likely the actual loss in sodded fields is greater than in most crops or forests. In considering the possible effects of forests as conservators of moisture, other and more important factors than evaporation from the soil must be considered. These include rainfall interception and transpiration.

It is also important to bear in mind that a comparison of forests with a sodded field may lead to conclusions which will not hold as regards the relation of a forest to a cropped field (of corn, for example).

In the forest the sum of the water losses is undoubtedly greater than in the ordinary meadow or pasture with short grass, for in the latter case interception and transpiration are relatively slight, even though the evaporation from the soil is materially greater than in the forest.

As to soil moisture, the author's experiments indicate less moisture in the surface layers in the open than in the forest, but more moisture in the open below 20 inches depth. Can it be fairly assumed that the moisture content in the forest is greater than in the open from these measurements, even though their numerical average does so indicate? If measurements at 4, 5, and 6 feet, or other depths down to the water table or rock had been taken, these would undoubtedly have shown results similar to those at 20 to 36 inches depth, and would have thrown the average of moisture content strongly in favor of the open field. Are not these results precisely what would be expected?

After a shower the moisture of the surface layers of the soil is more rapidly removed by evaporation in the open than in the forest, and the surface layers of the soil become dryer in the open. At greater depths, however, the smaller losses through interception and transpiration and other factors combined indicate that there should be, as was here found, a greater soil moisture below the influence of surface evaporation in the open.

Prof. Bode suggests that the soil in the forests was more open-textured than that in the open. Even a slight difference in this regard might vitiate the conclusions from such experiments. Soil moisture values are expressed as percentages of dry weights. The greater the porosity, therefore, the smaller the *actual volume* of water corresponding to a given dry weight moisture percentage. In other words, a slight excess of moisture percentage might be merely the result of an excess in porosity, without an actually greater water content.

It is unfortunate that this point was not determined, especially as observations along this particular line are very meager. Similar results have recently been published by Dr. Arnold Engler.[1]—*Robert E. Horton.*

TYPHOON IN THE PHILIPPINES.

By JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I., November, 1920.]

A destructive typhoon visited the Philippines at the beginning of November, causing much damage to property and to the crops in the Visayan Islands, Mindoro, and southeastern Luzon. Several small boats have been reported as either totally wrecked or badly damaged, with a corresponding considerable loss of life.

As no observations have been received as yet from Yap, Western Carolines, it is impossible to ascertain whether the typhoon was formed near that region of the Pacific Ocean or rather near the Philippines.[2] Clear signs of the existence of the typhoon and of its character as dangerous to the Visayas were noticed at Manila Observatory on November 2, and proper warnings sent out one day before the storm struck the easternmost part of the Visayas. The center of the typhoon must have been situated at 2 p. m. of the 2d near 130° longitude E. and 11° latitude N., moving almost due west. Shortly after noon of the 3d the typhoon reached the island of Samar, passing over, or very close to the south of, Borongan (125° 25′ longitude E., 11° 35′ latitude N.), where a barometric minimum as low as 729.52 mm. (gravity correction not applied) was observed at 12.30 p. m. The typhoon inclined slightly to the NW. while moving between Samar and Mindoro, so that at 6 a. m. of the 4th the center was situated near 121° longitude E. and in about 12° latitude N. The fury of the storm was particularly felt in Samar, northern part of Cebu and Negros, Masbate, Romblon, northern Panay, and Mindoro.

Once in the China Sea the typhoon moved again almost due west, and it reached Indochina in the morning of the 6th, the center being situated at 10 a. m. of that day in about 109° longitude E. and 13° latitude N.

The rate of progress of this typhoon while crossing the Philippines was of about 14 or 14.5 per hour.

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[1] Influences of Forests on Water Supply, Swiss Central Institute for Forest Investigations, vol. 12. Zurich, 1919.

[2] See reference to report of Dutch S. S. *Bali*, in review of the weather of the North Pacific Ocean for November, p. 667.